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Glossary of Terms: Image Data Compression

ISO - International Organization for Standardization
Founded in 1947, ISO is a worldwide federation of national standards bodies from some 130 countries, one from each country, and has almost 200 technical committees. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity. It issues standards on a vast number of subjects, ranging from nuts and bolts to image and video compression systems.

ITU - International Telecommunications Union (formerly CCITT)
Formerly known as the Consultative Committee on International Telegraph and Telephones (CCITT), and headquartered in Geneva, Switzerland ITU is an international organization within which governments and the private sector coordinate global telecom networks and services like fax and modems.

IEC - International Electrotechnical Commission
The International Electrotechnical Commission is the international standards and conformity assessment body for all fields of electrotechnology. Founded in 1906, the International Electrotechnical Commission (IEC) is the world organization that prepares and publishes international standards for all electrical, electronic and related technologies. The membership consists of more than 50 participating countries. The IECís mission is to promote, through its members, international cooperation on all questions of electrotechnical standardization and related matters, such as the assessment of conformity to standards, in the fields of electricity, electronics and related technologies.

JPEG - Joint Photographic Experts Group
A highly successful continuous-tone, still-picture coding international standard named after the Joint Photographic Experts Group that developed it. The JPEG standard (IS 10918-1/ITU-T T.81) was originally approved in 1992 and was developed as an official joint project of both the ISO/IEC JTC1 and ITU-T organizations.

JPEG-2000
A future new still-picture coding standard, JPEG-2000 is a joint project of the ITU-T SG8 and ISO/IEC JTC1 SC29 WG1 organizations. It is scheduled for completion late in the year 2000.

MPEG - Motion Pictures Experts Group
A highly successful image-sequence or video coding international standard named after the Motion Pictures Experts Group that developed it. The standard comes in various flavors like MPEG-1, MPEG-2, and MPEG-4 having different features, the main one being the bit rate. The MPEG-1 standard (IS 11172-2) was a project of the ISO/IEC JTC1 organization and was approved in 1993. MPEG-1 codec is capable of approximately videotape quality or better at about 1.5 Mbit/s. MPEG-2 forms the heart of broadcast-quality digital television (DTV). It's a step higher in bit rate, picture quality, and popularity. The MPEG-2 standard (IS 13818-2) was a joint project of the ISO/IEC JTC1 and ITU-T organizations and was completed in 1994. Its target bit-rate range is approximately 4-30 Mbit/s. MPEG-4 is currently under development.

Lossless and Lossy Image Compression
In lossless compression, the reconstructed image after compression is numerically identical to the

original image on a pixel-by-pixel basis. However, only a modest amount of compression is achievable in this technique. In lossy compression, on the other hand, the reconstructed image contains degradation relative to the original, because redundant information is discarded during compression. As a result, much higher compression is achievable, and under normal viewing conditions, no visible loss is perceived (visually lossless).

Predictive and Transform coding

In predictive coding, information already sent or available is used to predict future values, and the difference is coded. Since this is done in the image data or spatial domain, it is relatively simple to implement and is readily adapted to local image characteristics. Differential Pulse Code Modulation (DPCM) is one particular example of predictive coding. Transform coding, on the other hand, first transforms the image from its spatial domain representation to a different type of representation using some well-known transform like DCT and then codes the transformed values (coefficients). This method provides greater data compression compared to predictive methods, although at the expense of greater computations.

DCT - Discrete Cosine Transform

The DCT can be regarded as a discrete-time version of the Fourier-Cosine series. It is a close relative of DFT - a technique for converting a signal into elementary frequency components, and thus DCT can be computed with a Fast Fourier Transform (FFT) like algorithm in *O(n log n)* operations. Unlike DFT, DCT is real-valued and provides a better approximation of a signal with fewer coefficients. The DCT of a discrete signal $x(n)$, $n=0, 1, .. , N-1$ is defined as,

$$X(u) = \sqrt{\frac{2}{N}} C(u) \sum_{n=0}^{N-1} x(n) \cos\left(\frac{(2n+1)u\pi}{2N}\right)$$

where, $C(u) = 0.707$ for $u = 0$ and
$= 1$ otherwise.

DCT is very popular and used extensively in current image compression algorithms and standard.

DWT - Discrete Wavelet Transform

Wavelets are functions defined over a finite interval and having an average value of zero. The basic idea of wavelet transform is to represent any arbitrary function *É(t)* as a superposition of a set of such wavelets or basis functions. These basis functions or ëbaby waveletsí are obtained from a single prototype wavelet called the ëmother waveletí, by dilations or contractions (scaling) and translations (shifts). The Discrete Wavelet Transform of a finite length signal $x(n)$ having N components for example, is expressed by an N by N matrix.

Quantization

Quantization is simply the process of decreasing the number of bits needed to store a set of values (transformed coefficients, in the context of data compression) by reducing the precision of those values. Since quantization is a many-to-one mapping, it's a lossy process and is the main source of compression in a lossy image coding scheme. Quantization can be performed on each individual coefficient, which is known as *Scalar Quantization (SQ)*. Quantization can also be performed on a group of coefficients together, and this is known as *Vector Quantization (VQ)*. Both, uniform and non-uniform quantizers can be used depending on the problem at hand.

Entropy Encoder

An entropy encoder uses a model to accurately determine the probabilities for each input data value and

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produces an appropriate code based on these probabilities so that the resultant output code stream will be smaller than the input stream. In image coders an entropy encoder further compresses the quantized/predicted values losslessly to give better overall compression. Most commonly used entropy encoders are the *Huffman encoder* and the *arithmetic encoder,* although for applications requiring fast execution, simple run-length encoding (RLE) has proven very effective.

PSNR - Peak Signal-to-Noise Ratio

This is a quantitative measure of a lossy image coder.

$$\text{PSNR} = 10\log_{10}\left(\frac{E^2}{D}\right) = 10\log_{10}\left(\frac{255}{MSE}\right) \text{ dB, for an 8-bit image.}$$

MSE - Mean Square Error

This is the quantitative measure of error between the original and reconstructed images.

$$\text{MSE} = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\left|x(m,n) - \hat{x}(m,n)\right|^2$$